# PRODUCTIVITY OF WHITE–TAILED DEER IN OHIO[1]

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## ABSTRACT

Productivity of Ohio white-tailed deer (*Odocoileus virginianus*) was calculated from examination of 651 reproductive tracts obtained between 1951 and 1967. Adult doe (1.5+ years) breeding begins in late October and peaks between November 3 and November 16. Precocial-fawn does begin to conceive in mid-November, with 70 percent of fawn conceptions occurring between November 24 and December 21. Breeding activity reaches a peak about one week earlier north of latitude 40° compared with that in southern Ohio. Nearly 77 percent of the fawn does and all but one adult doe examined had ovulated. Precocial-fawn breeders averaged 1.29, yearlings 1.87, and adults 2.04 fetuses per breeder.

Ovum and embryo mortality for the first three months gestation averaged 11.5 percent for all age classes of does. Fawn mortality between mid-gestation and 5–7 months postpartum totaled at least 21.9 percent. Fawn and yearling does carried significantly more male than female fetuses, while the fetal sex ratio from 2+ year does was essentially 1:1. For all fetuses examined, the secondary sex ratio was 58.6 percent males. Male fawns die at a rate between 1.22 and 1.26 times greater than do females up through six months postpartum. A representative 100 Ohio does could produce 153 fetuses, while a representative 100 deer of both sexes could produce 74 fetuses. This theoretical increase rate of 74 percent, when compared with the actual rate of increase of about 20 percent since 1962, indicates that the annual mortality rate of the Ohio deer herd has been about 50 percent in recent years.

## INTRODUCTION

The size of the Ohio deer herd has been increasing rapidly in recent years in response to several factors. Since the late 1950's, the rapid expansion of the southern Michigan deer herd has provided the stock for a rapid building in deer numbers in northwest Ohio adjacent to Michigan (Nixon, 1970). In eastern Ohio, continued farm abandonment and subsequent secondary succession to brush and young forest has created more favorable deer habitat (U.S.D.A., 1967). Since 1964, in the unglaciated eastern deer range, Ohio's gun hunters have been restricted to shooting antlered bucks. Finally, more effort by law enforcement personnel and more restrictive laws pertaining to jacklighting and possession of illegal deer have combined to provide more protection for the entire deer herd.

The only earlier report on the breeding cycle and fecundity of the Ohio deer herd was provided by Gilfillan (1952, p. 5). He collected and reported on a sample of reproductive tracts from deer shot in January, 1951, primarily in northeast Ohio.

The present paper is based on a much larger sample of female reproductive tracts collected throughout the major deer range in Ohio. Estimates of natality in the Ohio deer herd are needed to evaluate the effects of various mortality factors, such as hunting and accidental deaths, on both regional and state-wide populations.

## METHODS

Female reproductive tracts were collected at checking stations from deer harvested during the hunting season. A few tracts were collected each year in 1953, 1959, and 1960, but the majority were collected during the hunting seasons of 1962, 1963, and 1964, when compulsory checking of harvested deer provided the opportunity to collect large samples. In addition, at intervals from 1962 to 1967, cooperating county game protectors collected female reproductive tracts from deer killed accidentally throughout the year. Most of the tracts were

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collected in eastern Ohio, but at least a few tracts were collected from nearly all of Ohio's 88 counties.

Ovaries were examined microscopically for current corpora lutea of pregnancy by slicing them into sagittal sections as described by Cheatum (1949). Each uterus was opened and searched for visible embryos or fetuses. Embryos and fetuses were sexed and aged, using growth criteria described by Armstrong (1950), and dates of conception and fawning were estimated for each pregnancy. Numbers of current corpora lutea were compared with visible embryos in individual does to determine preimplantation mortality; corpora albicantia were not counted because retention is not assured following a subsequent conception (Cheatum, 1949).

Ovulation rates and corpus luteum and fetus counts were initially separated on the basis of collection area. Three regions were used to compare productivity rates: glaciated western Ohio, less than 10 percent forested on soils derived from limestone; glaciated northeast Ohio, 20 percent forested, on soils derived from sandstone and shale; and the unglaciated hill counties, about 50 percent forested, on soils of sandstone and shale derivation.

Because of a hunting ban on antlerless deer in the hill counties, large samples of female deer have not been examined for age determination since 1964. However, recent sex-ratio counts derived from deer killed accidentally in the hill counties do not indicate that the buck harvests of 1965 through 1968 have significantly changed the sex ratios of the herd from the 1962-through-1964 period when hunters could shoot one deer of any age or sex (Anonymous, 1970). Does have been legally shot at intervals since 1965 in both northeast and northwest Ohio, and the sex and age structure of these herds has not changed significantly in recent years.

For this paper, samples of deer legally harvested during the 1962, 1963, and 1964 seasons and those killed accidentally throughout the year, also during 1962 through 1964, were examined to determine the sex ratios and the age structure of the Ohio deer herd. Hunting seasons were short, only two days in length during these years, and hunters tended to shoot deer as available, rather than selecting for larger and older animals. Even under these conditions fawns were found to be relatively more vulnerable to hunting then were adult deer.

Lower jaws were collected from all harvested and accidentally killed deer. These were used to age the deer, using the tooth replacement and wear criteria established by Severinghaus (1949).

Sex ratios were compared using Chi-square tests, while breeding dates and corpora lutea and fetal counts were compared using one-tailed "*Student t*" tests (Snedecor, 1956).

## RESULTS AND DISCUSSION

### *Dates of Conception and Parturition*

A total of 192 adult (1.5+ years) and 30 fawn pregnancies were sufficiently advanced to determine conception dates. As shown in Figure 1, breeding activity and conception for adult does begins in late October and peaks in early November. Precocial-fawn breeders begin to conceive in mid-November and breeding peaks in early December. About 90 percent of the adult does are bred between November 3 and November 30 each year. Seventy percent of fawn conceptions occur between November 24 and December 21 (fig. 1). Later conception for precocial-fawn breeders is the rule (Cheatum and Morton 1942), with breeding peaks for adult and fawn breeders about one month apart (Roseberry and Klimstra, 1970; Cheatum and Morton, 1946). Although most conceptions occur during the periods shown in Figure 1, breeding by individual does may occur at any time from September until April. A reliable sighting was made of very small triplet fawns in Athens County (southeast Ohio) in early April, 1967, indicative of a

September conception. Spotted fawns from early spring breeding are occasionally shot during Ohio's November and December hunting seasons, placing conception in March or April. These departures from normal breeding periods are presumably caused by irregularities in an individual doe's breeding cycle and occur in only a few deer each year.

Onset of breeding in white-tailed deer has been found by others to vary with latitude, with a progressively later fawning season in more southerly latitudes

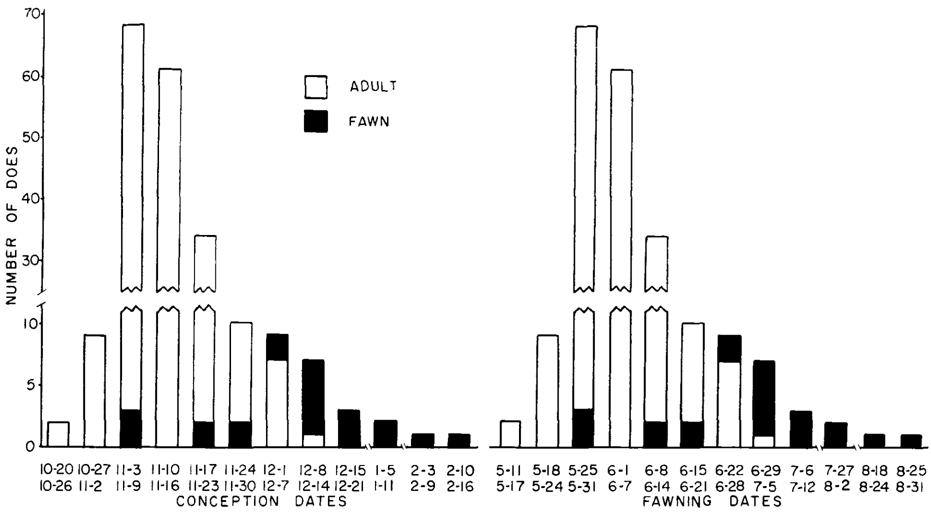


FIGURE 1. Time of conception and parturition by weekly intervals for 30 precocial fawns and 192 adult does.

(Severinghaus and Cheatum, 1956). Differences in breeding peaks may occur even over a relatively small geographic area, as reported for different areas in New York and in North Carolina (Cheatum and Morton, 1946; Weber, 1966). These differences in breeding peaks have been attributed to variation in photoperiod, rather than to latitude *per se* (McDowell, 1970). To determine if such differences in breeding activity also occur in Ohio, I divided the adult doe pregnancies into two groups, using latitude 40° north as the separation line between northern and southern Ohio. This subdivision revealed that breeding activity peaks about one week earlier in northern Ohio (November 3–9, $N=116$), than it does in southern Ohio (November 10–16, $N=76$). Gilfillan (1952) also found that breeding activity peaked in early November in northeast Ohio.

### *Ovulation and Fetal Rates*

No significant differences ($P>0.05$) in ovulation rates were found among the three regions for fawn, yearling, or adult does. No significant difference in mean number of corpora lutea per doe was found within any age-class, although corpus luteum counts in fawn and yearling does from western Ohio averaged higher than did those from eastern Ohio animals. Yearling does from western Ohio also carried a significantly higher ($P<0.05$) mean number of live fetuses than did yearling does in the hill country. A significantly higher ($P<0.05$) mean number of live fetuses was found in northeast precocial-fawn breeders than in both western and hill-country-fawn breeders. No significant differences were found in mean number of live fetuses carried by adult does in the three regions. Because of close similarities among all regions in ovulation and corpus luteum counts and the relatively small sample sizes (N<30) for the different fetal counts, samples from all regions were combined and treated as one sample.

Ovulation rates and primary corpus luteum and fetus counts for three age-classes of does are shown in Table 1. No significant differences (P>0.05) in mean corpus luteum or fetal counts were found among 2-, 3- and 4-year-old does, so all does older than 28 months were combined in the adult age-class.

TABLE 1

*Ovulation rates and corpus luteum and fetus counts by doe age-class in Ohio*

| Breeding Age of Does (months) | Number of Does | Ovulation Rate (percent) | Number of Does | Number of Current Corpora Lutea | | | | Mean Number of Corpora Lutea Per Doe | Number of Does* | Number of Fetuses | | | | | Mean Number of Fetuses Per Doe | Ova Loss** (percent) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | | | 1 | 2 | 3 | 4 | 5 | | |
| 5–8 | 335 | 76.7 | 257 | 194 | 61 | 2 | – | 1.25 | 98 | 70 | 28 | — | – | – | 1.29 | 13.3 |
| 16–18 | 180 | 99.4 | 179 | 16 | 139 | 24 | – | 2.04 | 126 | 30 | 83 | 12 | 1 | – | 1.87 | 9.3 |
| 28+ | 215 | 100.0 | 215 | 10 | 149 | 54 | 2 | 2.22 | 210 | 20 | 166 | 21 | 2 | 1 | 2.04 | 12.3 |

*Does with gestation sufficiently advanced to provide accurate fetus counts.

**Ova loss computed only for those does with visible embryos and both ovaries available for examination. Sample size by age class: Fawns—21; yearlings—49; adults—89.

Both ovulation and conception rates have been found to increase with age in white-tailed deer, at least until the doe reaches the third autumn, or about 28 months of age (Sileo, 1966). Significant differences (P<0.05) were found in the mean numbers of corpora lutea and fetuses carried by precocial fawn, yearling, and adult does (Table 1).

Slightly more than 75 percent of the 335 fawn does examined had ovulated prior to death (Table 1). Virtually all yearling and adult does ovulate and conceive each year in Ohio. Only one yearling examined had not ovulated, while all the adult does examined had ovulated (Table 1). Yearling does averaged slightly over two corpora lutea and nearly two fetuses per doe. Seventy-five percent of the yearling pregnancies were multiple, with nearly 10 percent consisting of triplets. Virtually all adult does carried at least two fetuses and more than 10 percent carried three or more (Table 1).

Haugen and Trauger (1962) found that 83.6 percent of a sample of 140 fawn does in Iowa had ovulated, the only published data I have found on precocial-fawn breeding with a higher rate than that of Ohio fawn does. The quality of habitat available to deer has been found to influence conception rates of all age-classes, but it particularly affects those of fawn breeders. On ranges offering diets of poor quality, precocial-fawn does seldom breed, and fecundity is lower in older does compared with does on a more nutritious diet (Severinghaus and Cheatum, 1956). The fertility rates shown in Table 1 for Ohio deer are indicative of good nutrition for all age-classes. Does from western Ohio were found to ovulate and conceive at a slightly higher rate than did does from eastern Ohio. The annual nutritional plane of does in western Ohio is also somewhat higher than for does in eastern Ohio (Nixon *et al.*, 1970). Deer productivity is largely controlled by the quality of the annual diet available to the doe (Verme, 1969, p. 881) and western Ohio does ingest large amounts of foods produced on very productive farmlands (Nixon *et al.*, 1970).

There were two cases of apparent polyovular follicles or homozygous twinning. A 3¼-year-old doe shot in December, 1953, in Geauga County contained three fetuses (three separate chorions) in the same uterine horn, but only two primary corpora lutea in the corresponding ovary. Another doe, also 3½ years old, shot in December, 1962, in Muskingum County, had two embryos in separate chorions in the same horn, but only one corpus luteum in the corresponding ovary.

An adult (age unknown) doe, shot in January, 1951, in Summit County, contained five living fetuses. The doe had conceived during the week of November 10–16, 1950. Three does examined contained four live fetuses each: an adult doe, shot in January, 1951, in Lake County; a yearling doe killed by a car in May, 1967, in Trumbull County; and an adult doe killed by a car in February, 1962, in Vinton County.

### *Ovum Loss and Fetal Mortality*

A comparison between current corpora lutea and living fetuses provides an estimate of ovum loss between ovulation and successful implantation. As shown in Table 1, precocial fawns experienced the highest mortality of ova, followed closely by adult and yearling does. Roseberry and Klimstra (1970) reported a similar pattern in a herd from southern Illinois: lower ovum losses for yearlings compared with fawn and adult breeders.

The average ovum loss of 11.5 percent, calculated for all age-classes, represents mortality from ovulation through about three months of pregnancy (from mid-November until mid-January); 74 percent of all tracts examined were collected in November, December, and January. Insufficient samples were obtained for the last three to four months of pregnancy to enable uterine mortality to be calculated for the last half of the gestation period. However, it is apparent that fetal losses are low after the third month. I examined 113 pregnancies advanced beyond the third month and found only one dead fetus. Robinette *et al.* (1955) found that most uterine losses occurred prior to mid-pregnancy in mule deer.

### *Fawn Mortality*

Fawn mortality is probably greatest in the first 48 hours after birth, primarily as a result of nutritive failures of various types (Verme, 1962). In an attempt to determine the extent of postpartum fawn mortality in Ohio, the fetus:doe ratio was compared with fawn:doe ratios from three sources: (1) accidental kills occurring

TABLE 2

*Fawn:doe ratios computed from various sources in Ohio*

| Source | Number of Breeding Does | Number of Fetuses or Fawns | Number of Fetuses or Fawns Per Doe | Percent Change from Fetus Counts |
|---|---|---|---|---|
| *In utero* | 434 | 790 | 1.82 | |
| Accidental kills (June 1–Nov. 30, 1962–1967) | 535 | 762 | 1.42 | 21.9 |
| Accidental kills (entire year, 1962–1964) | 270 | 490 | 1.81 | 1.0 |
| Harvest (1962–1964) | 689 | 1139 | 1.65 | 9.3 |

from June through November 30 each year, the period between parturition and the hunting season when most fawn mortality occurs; (2) the accidental kill for the entire year; and (3) the legal harvests for 1962, 1963, and 1964, when deer of any sex or age were legal. The resultant fawn:doe ratios are shown in Table 2. The June-through-November accidental-kill ratio of fawns per doe indicates a 21.9 percent decline from the prepartum fetus:doe ratio. Even this estimate is probably low, in light of Verme's estimate of a 10- to 20-percent early postpartum loss of fawns even for well-conditioned does (Verme, 1962). Data from the total accidental kill and the legal harvest do not provide a reasonable estimate of fawn mortality because of greater vulnerability of fawns to shooting and accidental deaths relative to their numbers in the population. Fetus counts indicate that more than 10 percent of the adult does carry triplets (Table 1), yet I have observed very few postpartum family groups with three fawns, presumably because of high postpartum mortality following multiple births.

### *Secondary Sex Ratios*

The secondary sex ratio, or sex ratio in mid-to-late gestation, of Ohio fetuses is shown in Table 3 by maternal age-class. Both fawn and yearling does were found to carry significantly more male than female fetuses. The fetal sex ratio from adult does did not differ significantly from the expected 1:1 (Table 3). Precocial-fawn breeders have been found to carry a significantly higher number of male fetuses than do adult breeders (McDowell, 1962). Does on a good nutritional plane usually produce more male fawns than females because prepartum mortality, in which more males than females are lost, is low (Robinette *et al.*, 1957). It seems probable that, for Ohio does, both maternal age at conception and low intrauterine mortalities exert the most influence on fetal sex ratios and combine to produce significantly more males than females at birth.

TABLE 3

*Secondary sex ratios, by doe age-class, in Ohio*

| Breeding Age of Does (months) | Number of Does | Number of Fetuses | Sex of Fetuses | | | | ♂♂:100 ♀♀ |
|---|---|---|---|---|---|---|---|
| | | | ♂♂ | Percent | ♀♀ | Percent | |
| 5–8 | 49 | 58 | 37 | 63.7* | 21 | 36.2 | 176.1 |
| 16–18 | 30 | 61 | 39 | 64.0* | 22 | 36.0 | 177.2 |
| 28+ | 60 | 125 | 67 | 53.6** | 58 | 46.4 | 115.5 |
| Total | 139 | 244 | 143 | 58.6* | 101 | 41.4 | 141.5 |

*Significantly different from 1:1 sex ratio ($P<0.05$).
**Fetal sex ratio from adult does not significantly different from 1:1 sex ratio ($P>0.05$).

When fetal sex ratios are compared with sex ratios of fawns either accidentally killed or legally harvested, it appears that more postnatal male fawns die than do females, at least up to six months of age (Table 4). The sex ratio drops from 58.6 percent males prepartum to near unity after the first 6–8 months postpartum. This change in sex ratio would require a mortality rate for males of between 1.22 and 1.26 times that of females (Table 4).

TABLE 4

*Sex ratios (in percent) of fawns shot legally and fawns killed accidentally January 1962–December 1964*

| Legal | | | Accidental | | |
|---|---|---|---|---|---|
| Sample Size | Percent ♂♂ | ♂♂:100 ♀♀ | Sample Size | Percent ♂♂ | ♂♂:100 ♀♀ |
| 1139 | 52.8 | 112.1 | 490 | 53.7 | 115.8 |

### *Productivity*

Estimates of productivity for a representative 100 Ohio does and a representative herd of 100 deer of both sexes are shown in Table 5. These calculations indicate that a representative 100 does could theoretically produce 153 fetuses, while 100 deer of both sexes could produce 74 fetuses or a theoretical annual rate of increase of 74 percent each year. Gilfillan (1952) calculated a theoretical rate of increase of 72 percent for the northeast Ohio deer herd.

TABLE 5

*Productivity of the Ohio deer herd using a sample of 100 females and 100 deer as base population*

| 100 Females Only | | Breeding Age (months) 5–8 | 16–18 | 28+ |
|---|---|---|---|---|
| Number in each age-class | | 45 | 25 | 30 |
| Number does breeding | | 35 | 25 | 30 |
| Number fetuses per doe | | 1.29 | 1.87 | 2.04 |
| Total number fetuses | | 45 | 47 | 61 |
| Total fetuses per 100 does | =153 | | | |
| 100 Deer Both Sexes* | | | | |
| Number does per 100 deer | 48 | | | |
| Number fawn breeders | 16 | | | |
| Number yearling breeders | 12 | | | |
| Number adult breeders | 15 | | | |
| Number fetuses, fawn breeders | 21 | | | |
| Number fetuses, yearling breeders | 22 | | | |
| Number fetuses, adult breeders | 31 | | | |
| Total fetuses per 100 deer | = 74 | | | |
| Theoretical rate of increase | = 74 percent | | | |

*Age structure taken from 1962, 1963, and 1964 deer harvest records; 5,510 shot; 2,859 aged by year class using tooth replacement and wear (Russell, 1966).

An estimate of the actual rate of deer-population change each year may be obtained by comparing the annual state-wide highway deer kill for a number of years. Deer kills are converted to natural logarithms and the linear regression calculated, the slope $b$ providing an estimate of the average rate of change between years (McNeil, 1962). Correction must be made for the annual increase in new highway construction and vehicular travel each year. Since 1965, the annual rate of increase in highway deer kills in Ohio has averaged 23.1 percent, while vehicular travel and highway construction have increased about four percent each year. Simple substraction indicates that the actual rate of increase of the Ohio deer herd averaged nearly 20 percent for this period.

Productivity, or the replacement rate of a population, may also be calculated, using the number of female progeny produced per female breeder (Slobodkin, 1961). As shown in Table 6, the replacement rate for the Ohio deer herd is 1,259 females produced from a base of 1,000 female breeders. The rate of increase would be 20.6 percent (259 of 1,259) and agrees closely with the rate estimated from highway mortality. Both deer track counts in snow and aerial censuses of the deer population conducted in selected townships throughout Ohio each winter since 1965 have confirmed this rate of increase. If this rate of increase is subtracted from the theoretical rate of 74 percent (Table 5), an annual mortality rate of about 50 percent would be indicated for the entire deer herd. Of course, this figure represents all herd mortalities, beginning early in the gestation period. Known mortalities in 1969 totalled nearly 4,500 deer, or 18 percent of the estimated herd. Early postpartum losses probably account for much of the remaining mortality, although poaching, dogs, and accidents undoubtedly account for many unreported deaths each year.

TABLE 6

*The average annual replacement rate of the eastern Ohio deer herd for the years 1962, 1963, and 1964 calculated from female survival and production of female progeny*

| Age of Doe (years) | Female Age Composition* | Survival Series $l_x$ | Number of Females Produced Per Female** $m_x$ | $l_x.m_x$ |
|---|---|---|---|---|
| 0–1 | 537 | 1,000 | .34 | 340 |
| 1–2 | 303 | 562 | .67 | 377 |
| 2–3 | 191 | 315 | 1.02 | 321 |
| 3–4 | 124 | 159 | 1.02 | 162 |
| 4+ | 71 | 58 | 1.02 | 59 |
| | | | | Σ1,259 |

*Russell (1966).

**Productivity derived from number of breeders per age-class (Table 1), the number of fetuses per breeder (Table 1), and the sex ratio of the fetuses by age-class (Table 3).

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